

# **Unit 1**

## **Biochemistry**

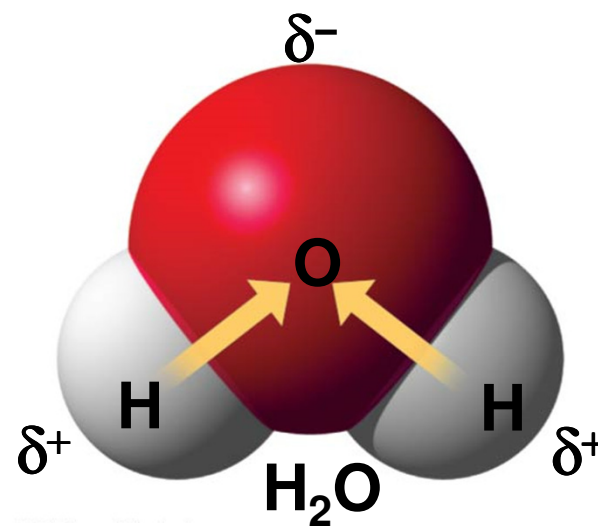
### **Chapter 2: The Chemical Context of Life**



# Chemical Bonding

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- **Ionic bond**
  - Transfer of electrons
- **Nonpolar covalent bond**
  - Atoms share the electron *equally*
- **Polar covalent bond**
  - One atom is more electronegative so the atoms do *not* share the electron equally
  - Causes a partial positive or negative charge for each atom or molecule
    - Ex: Water





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- **Hydrogen bond**

- Weaker but have important biological roles

- Hydrogen bonds between nitrogenous bases hold one strand of DNA to the other, while still allowing the strands to “unzip” for replication
    - Cohesion of water molecules

- A molecule's *shape* is usually very important to its *function*



# Chemical Reactions

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- **Chemical reactions** are the making and breaking of chemical bonds
- Matter is conserved in a chemical reaction
  - Reactions cannot create or destroy matter but can only rearrange it!
- All chemical reactions are reversible
- One of the factors affecting the rate of a reaction is the concentration of the reactants
- **Chemical equilibrium** is reached when the forward and reverse reaction rates are equal
  - No net change



# Properties of Water

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- Water is a **polar molecule**
  - Properties of water arise from attractions between oppositely charged atoms of different water molecules
- Two water molecules are held together by a hydrogen bond
- Four emergent properties of water contribute to Earth's suitability for life:
  1. Cohesive behavior
  2. Ability to moderate temperature
  3. Expansion upon freezing
  4. Versatility as a solvent



# 1. Cohesive Behavior

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- **Cohesion**

- Water attracted to water

- **Adhesion**

- Clinging of water to another substance

- Both help transport water and nutrients in plants against force of gravity



## 2. Moderation of Temperature

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- Water has high **specific heat capacity**
  - Can absorb or release a large amount of heat with only a slight change in its own temperature
- **Evaporative cooling**
  - Water helps stabilize temperatures in bodies of water and organisms by preventing overheating



### 3. Expansion Upon Freezing

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- Ice floats in liquid water because hydrogen bonds in ice are more “ordered,” making ice less dense
  - Ice also insulates liquid water below



## 4. Universal Solvent

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- Water is a versatile solvent due to its polarity, which allows it to form hydrogen bonds easily
- **Hydrophilic** = “Water loving”
- **Hydrophobic** = “Water fearing”
  - Oil molecules are hydrophobic because they have relatively nonpolar bonds



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- **Acids** increase the  $\text{H}^+$  concentration in water
    - Acidic solutions have pH values less than 7
      - The lower the number, the more acidic the solution
  - **Bases** reduce the concentration of  $\text{H}^+$ 
    - Basic solutions have pH values greater than 7
  - Remember, each pH unit represents a TENFOLD difference in  $\text{H}^+$  and  $\text{OH}^-$  concentrations
    - When the pH of a solution changes slightly, the actual concentrations of  $\text{H}^+$  and  $\text{OH}^-$  in the solution change substantially!



# **Unit 1**

## **Biochemistry**

Chapter 3: Carbon and the  
Molecular Diversity of Life



# Carbon Compounds

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- **Organic compounds**
  - Contain carbon chains
- Carbon is versatile because it can form 4 covalent bonds
- **Functional groups** are the components of organic molecules that are most commonly involved in chemical reactions



Figure 3.5a


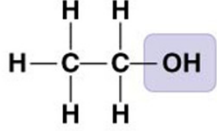
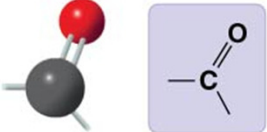
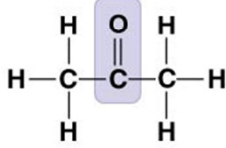
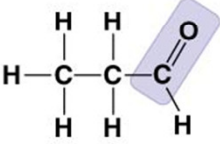
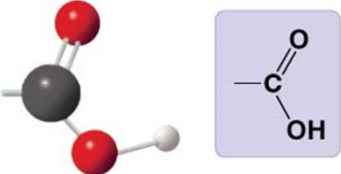
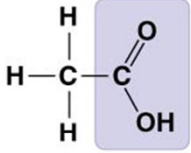
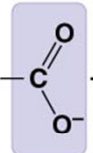

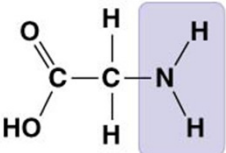
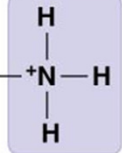
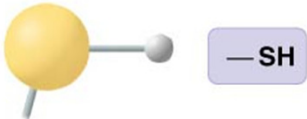
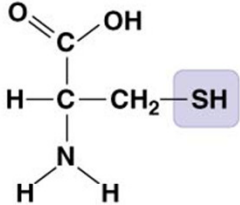
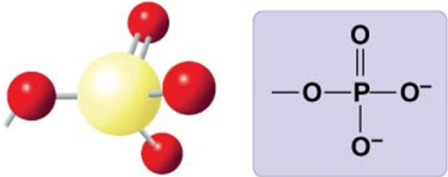
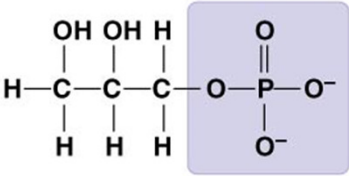
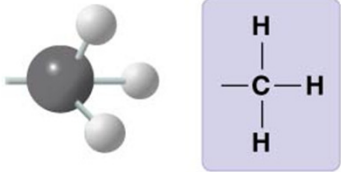
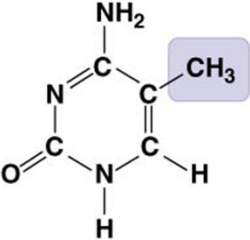
Chemical Group	Compound Name	Examples
<b>Hydroxyl group (<math>\text{—OH}</math>)</b> 	<b>Alcohol</b>	 <b>Ethanol</b>
<b>Carbonyl group (<math>\text{&gt;C=O}</math>)</b> 	<b>Ketone</b>  <b>Aldehyde</b>	 <b>Acetone</b>  <b>Propanal</b>
<b>Carboxyl group (<math>\text{—COOH}</math>)</b> 	<b>Carboxylic acid, or organic acid</b>	 <b>Acetic acid</b> $\rightleftharpoons$  $+ \text{H}^+$
<b>Amino group (<math>\text{—NH}_2</math>)</b> 	<b>Amine</b>	 $+ \text{H}^+ \rightleftharpoons$  <b>Glycine</b>



Figure 3.5b

Chemical Group	Compound Name	Examples
<b>Sulfhydryl group (<math>\text{—SH}</math>)</b> 	Thiol	 <b>Cysteine</b>
<b>Phosphate group (<math>\text{—OPO}_3^{2-}</math>)</b> 	Organic phosphate	 <b>Glycerol phosphate</b>
<b>Methyl group (<math>\text{—CH}_3</math>)</b> 	Methylated compound	 <b>5-Methyl cytosine</b>



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- **Polymers** are built from many building blocks called **monomers**
  - **Dehydration reaction =**
    - *Joins* monomers together into polymers through the *loss* of a water molecule
  - **Hydrolysis =**
    - *Disassembles* polymers into to monomers through the *addition* of water
    - Ex: Digestion
  - These processes are facilitated by **enzymes**, which speed up chemical reactions



Figure 3.6a

**(a) Dehydration reaction: synthesizing a polymer**

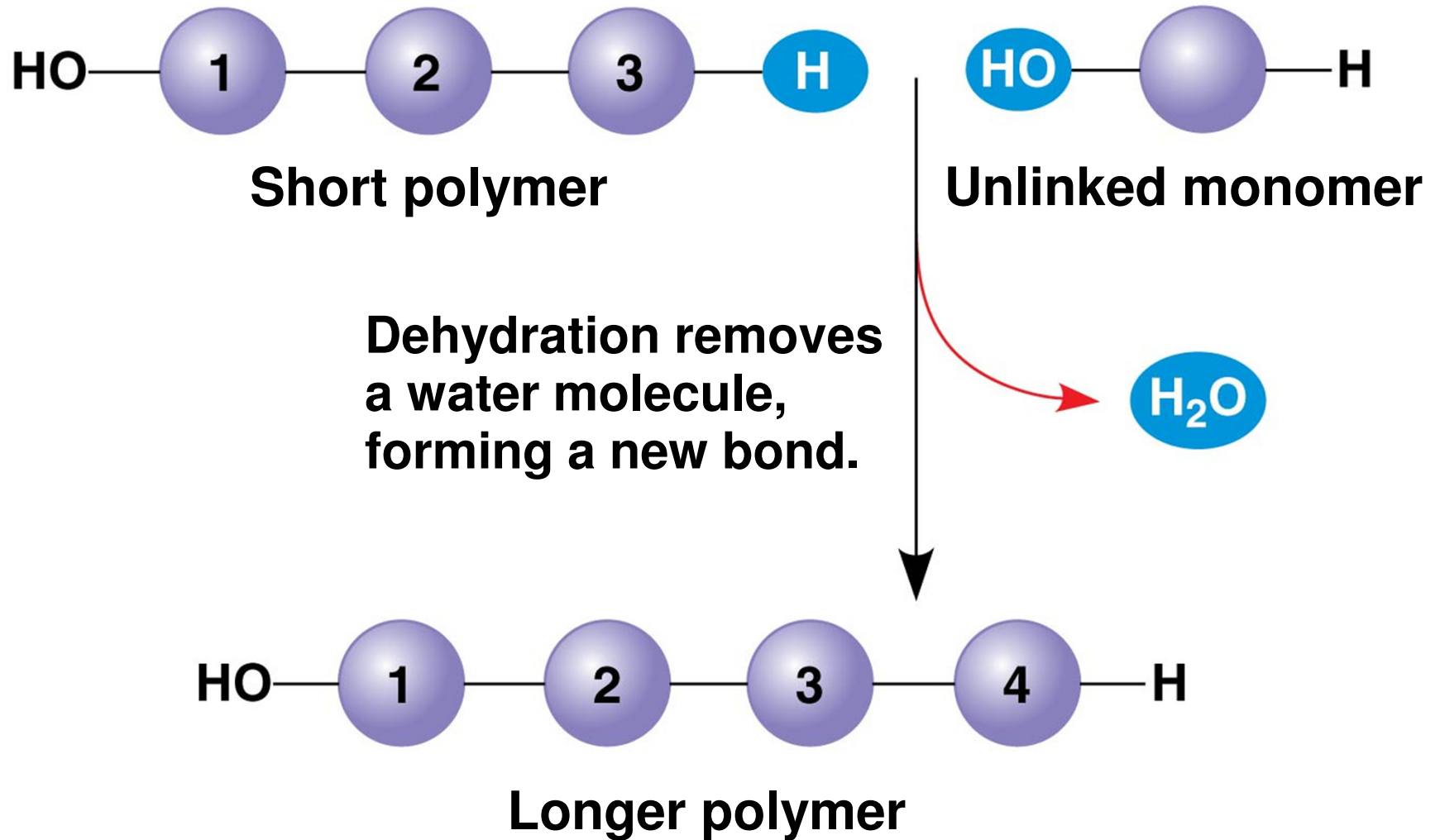
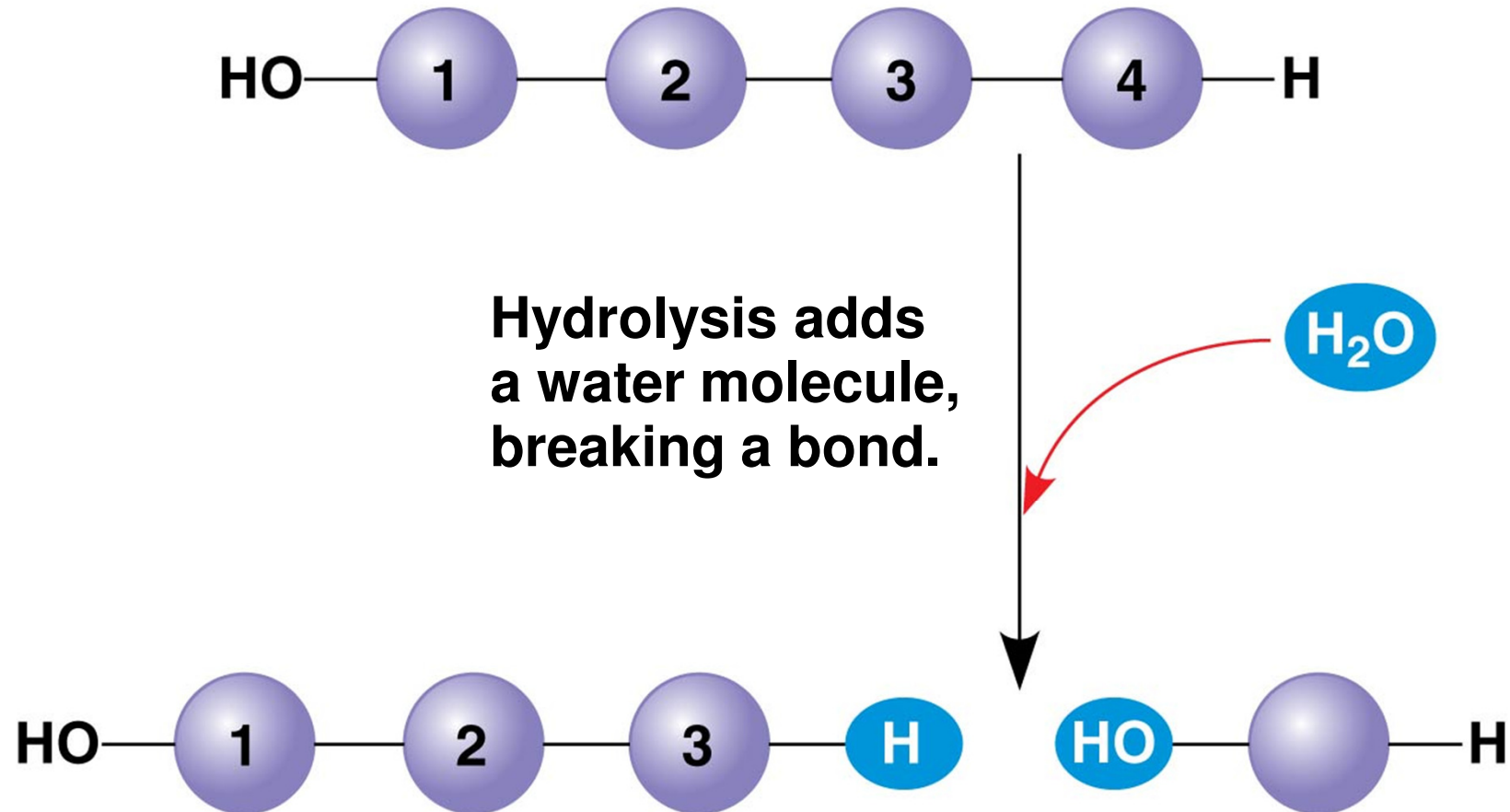




Figure 3.6b

**(b) Hydrolysis: breaking down a polymer**





# Overview of Macromolecules

Macromolecule	Monomer	Function
Carbohydrates		
Lipids		
Nucleic Acids		
Proteins		



# Carbohydrates

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- **Carbohydrates** include sugars
- The simplest carbohydrates are **monosaccharides**, or simple sugars
- Carbohydrate macromolecules are **polysaccharides**
- Fuel and building material



# Lipids

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- **Lipids** are hydrophobic because they consist mostly of hydrocarbons, which form nonpolar covalent bonds
- The most biologically important lipids are fats, phospholipids, and steroids
- Fats = energy storage
  - **Saturated fatty acids** have the maximum number of hydrogen atoms possible and no double bonds
  - **Unsaturated fatty acids** have one or more double bonds
- Phospholipids = make up cell membrane



# Proteins

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- Protein functions include
  - Defense, storage, transport, structural support, movement, cellular communication
  - Catalysts
    - **Enzymes** speed up chemical reactions without being consumed by the reaction
- Protein shape affects function!
  - Changes in pH, salt concentration, temperature, or other environmental factors can cause a protein to unravel (**denaturation**)
  - A denatured protein is biologically inactive!



# Nucleic acids

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- DNA and RNA
- Nucleic acids store, transmit, and help express hereditary info
  - Flow of genetic information:
    - DNA → RNA → Protein
- Building blocks (**nucleotides**) are composed of
  - Sugar
  - Phosphate
  - Nitrogenous base



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- DNA is double stranded
  - RNA is single stranded
  - The sugar in DNA is **deoxyribose**
  - The sugar in RNA is **ribose**
  - DNA contains base thymine
    - A pairs with T
    - C pairs with G
  - RNA contains base uracil
    - A pairs with U